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TITLE: Automatic door for mines - has series doors each with polarized relay arranged to isolate other door operating mechanisms when one door is opened

PATENT-ASSIGNEE: COAL IND PATENTS LTD[COAL]

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ABSTRACTED-PUB-NO: GB 1485981A

BASIC-ABSTRACT:

The automatic door system, especially for ventilated underground mines, has safety and operational interlocks. In a tunnel door sets are provided at intervals. Associated with each door set (1) is an opening switch (16) associated with a polarized relay. Each door set (1) has an operating mechanism, eg a ram and a closing switch (17).

The relay of each door set (1) is connected with the operating mechanisms of the other door sets. Indicators, such as red and green lights (R, G) are associated with each door set. In use, when a given door set opening switch is operated, the associated relay disables the operating mechanisms of the other door sets and the appropriate lights are energised. Pressure doors (12) open to equalize pressures on opposite sides of the given door set prior to their opening. Closing sequences are interrupted if a person is present on a tread plate (8, 9) associated with the door set.

TITLE-TERMS: AUTOMATIC DOOR MINE SERIES DOOR RELAY ARRANGE ISOLATE DOOR OPERATE MECHANISM ONE DOOR OPEN

DERWENT-CLASS: Q47

1 485 981

PATENT SPECIFICATION (11) 1 485 981

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(19)

(54) AN AUTOMATIC DOOR OPERATING SYSTEM

(71) We, COAL INDUSTRY (PATENTS) LIMITED, a company organised in accordance with the laws of Great Britain, of Hobart House, Grosvenor Place, London S.W.1., England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an automatic door operating system comprising, in combination, a plurality of doors spaced apart from each other in line in a tunnel and electrical circuitry interlocking the doors.

The invention finds particular, but not exclusive, application in Mines and Underground tunnels which are force-ventilated by drawing air from a down-draught air shaft, through the mine or tunnel system and up an up-draught shaft. It is important that the air is guided around the tunnel system in a correct sequence and that no possibility should occur for the air from the two shafts to go directly from one shaft to another. To achieve the proper circulation a system of doors are provided in the system and, particularly adjacent the shafts, the doors comprise two or three sets of doors arranged in tandem so that only one door can be opened at any one time and short-circuiting the air system is impossible.

Furthermore, the pressures used may be as high as 18 inches water gauge pressure and thus the doors are biased closed with a substantial force on standard airlock systems. If a door in the system is opened, for example, by pushing with a truck, and another door is closing as somebody passes through, this other door may close quickly trapping and injuring the person passing through. To avoid this, on the power operated air door system, pressure relief or escape doors have been incorporated in the doors to establish pressure equalization on either side of a door before it is opened.

It is an object of the present invention to provide an improved control system which overcomes or reduces the disadvantages of presently available systems.

According to the present invention in an automatic door operating system comprising at least three doors spaced apart from each other in line in a tunnel and electrical circuitry interlocking the doors, the electrical circuitry comprises, in respect of each door, first switch means adapted to initiate opening of the door, second switch means adapted to initiate closing of the door, polarized relay means associated with each first switch means, and operating means respectively for the doors; the relay means of each door being connected with the operating means of the other doors in such a manner as to isolate the said operating means of the other doors when one of the doors is opened; indicating means associated with each door arranged to indicate whether or not the operating means for that door is isolated and further switch means connected to prevent closure of a door when an object is passing through, or within a predetermined distance of the door.

The operating means may be electro-pneumatic or hydraulic valves controlling a piston and cylinder arrangement.

The indicating means are preferably lamps although they could be other visual warning indicators, such as signals, or audible warning means, or a combination of visual and aural means. The indicating means are preferably relay operated.

Further switching means may be incorporated to prevent closing of a door while an object or person is passing through the door. Said switching means may be a switch directly operated by the weight of the person or object.

Further valve means may be incorporated to initiate a pilot action, such as the opening of an air escape hatch, before the door opens. Such a pilot action may be used to control the operating means.

In order that the invention may be readily understood one example of an automatic door operating system for three sets of power-operated doors will now be described, by way of example only, with

reference to the five figures of the drawings accompanying the provisional specification. In the drawings Figure 1 shows an isometric view of one set of doors in the open position, Figures 2 and 3 show respectively electrical logic circuits for opening and closing the doors, Figure 4 shows the electrical logic circuit for operating the escape, or pressure relief doors and Figure 5 shows the logic circuit for the indicating lights.

In this example three identical sets of doors are provided to present an air barrier in a mine tunnel and to prevent a direct connection between the air inlet and the air exhaust systems of the mine. The doors are sealed into the main roadway of the mine adjacent the shaft, and each set of doors is separated from its adjacent set by a distance of about 25 yards. Since all three sets of doors are identical only one set is shown in Figure 1 and the three sets are identified herein, as A, B and C. As seen in Figure 1 each set of doors comprises a pair of doors 1 hinged to a bulwark 2 secured in an airtight manner to the sides of a mine wall 3. A top girder 4 carries a triangular top plate 5 which acts as a stop for the doors 1 and above which moves a pneumatic piston and cylinder arrangement 6 for operating the doors 1. A pair of rails 7 for mine tubs runs through the doors, below them when closed, and between the rails and below the plate 5 is situated a spring-loaded tread plate 8 having a triangular front end aligned with and corresponding in shape to the plate 5. The tread plate 8 carries below it (not shown in Figure 1) a switch which operates to maintain the doors 1 open if any person treads on the plate 8 while the doors 1 are closing. It will be appreciated that the doors 1 when closed are in V-formation with the point of the V in the direction of high air pressure or pointing up stream of the air flow. A second tread plate 9 similar to tread plate 8 with a separate switch is located in front of the doors 1 and in such a position that a person standing on the plate 9 will not be touched by movement of the doors. Stops 10 limit the opening of the doors 1.

Each set of doors includes an escape or pressure relief door 12. This door 12 is provided so that the pressure on each side of the bulwark 2 can be equalized before the doors 1 are opened. The doors 12 are operated by a pneumatic cylinder although, in cases of power failure, they can be operated by hand. The pneumatic cylinders are controlled and supplied by a pneumatic system generally indicated at 13 and controlled by electro-pneumatic valves. An override and test box 14 is provided for emergency and test use.

Adjacent each set of doors and on either side of the bulwark a control box 15 is provided. This contains dual red lights R and dual green lights G and open and close switches 16 and 17 respectively for the doors 1.

In operation all three sets of doors are normally shut. Thus a person approaching the first set of doors A with all the doors closed will see the green light of control box 15 illuminated. Similarly all the other control boxes will show green. The person then operates switch 16 which first causes door 12 to open to equalize the air pressure on either side of the set of doors A and then operates cylinder 6 to open the main doors. As soon as switch 16 is operated the lights on all the doors go to red. When the main doors are open and proved open by the logic circuitry lights are changed to green for door 1 only; the lights on all other doors remain on red. The person then passes through the doors and operates switch 17 of the control box 15 on the other side of the bulwark 2 and the green lights of this door extinguish and the red lights illuminate. The doors 1 of set A now close and door 12 closes. When the main door has been proved closed the light R is extinguished and light G is illuminated. The other lights remain unchanged. The person now approaches the set of doors B and operates switch 16 of the control box for that set of doors. The door 12 of the set of doors B first opens to equalize the pressure on either side of the set of doors B before these main doors open. The person passes through, closes the doors and proceeds to the final set of doors C where the operation is repeated.

If, at any time when a person is operating a switch 17 to close an associated set of doors another person attempts to get through the doors, there is no risk of that other person being trapped by the doors since they will, in trying to pass between doors 1, have to tread on plates 8 or 9. As soon as there is any weight on either of these plates the closing sequence is interrupted and the doors re-open.

The sets of doors are interlocked so that it is impossible for two doors to be opened at the same time. The use of the lights on the control system indicates to other people on opposite sides of the doors that someone else is in the door system and the electrical circuitry is such that priority is given to the person who first operated a switch consistent with the safety conditions required concerning the opening of sets of doors.

Bearing this general system of operation in mind reference will now be made to the logic system of the electrical circuitry shown in detail in Figures 2 to 5. Each set of doors has a similar circuit to the other sets of doors and relies on a polarized relay PR1

and associated contacts which are closed in one condition of the relay and open in the reverse condition. In the figures the contact notation N indicates the contacts are closed in the normal condition of the relay and the notation R indicates the contacts are closed when relay is in its reversed condition. The notation EPV indicates an electro-pneumatic valve which is used for controlling doors 1 and 12. R indicates relays. EPV and R are both normal biased to set conditions and when operated are held off these conditions but revert to them when the operation ceases. LR indicate relays associated with the warning light circuits. The suffixes A, B and C are used to identify the respective sets of doors.

The operation of the circuit will now be described to follow the sequence of operation described with reference to Figure 1. In Figure 2 current is supplied from a 15 volt a.c. source 20 to a full-wave rectifying bridge 21 and from there to three parallel and similar circuits for each set of doors.

Considering first the operation of door A, with the door closed the polarized relay (PR1(A)) is set to its normal condition so that contacts PR1(A)N are closed and PR1(A)R are open. Similar conditions exist in respect of PR1(B) and PR1(C). The escape door 12 of each set of doors is closed and respective contacts PVA4, PVB5 and PVC6 associated with the pneumatic valves (PV) of those doors are closed so that connected relays R4, R5 and R6 respectively are energized from rectifier 21 and their associated contacts are closed. Relays R1, R2, R3 associated respectively with the door closing circuits of sets of doors A, B, C are not energized and their associated contacts are thus open.

Therefore, considering the A part of the circuit of Figure 2, it will be seen that contacts PR1(B)N, PR1(C)N, R5A1, R6A1 and PR1(A)N are closed together with switch PVA1 which proves that the set of doors A is closed. Contacts PR1(A)R and R1A1 are open. If one of the switches 16 is now closed to open the A set of doors a circuit will be completed from the positive side of bridge 21 through PR1(B)N, PR1(C)N, R5A1, R6A1,16, PR1(A)N, PR1(A), PR1(A)N and PVA1 to the negative side of bridge 21. Polarized relay PR1(A) will thus be energized and will reverse opening contacts PR1(A)N and closing contacts PR1(A)R.

Referring now to Figure 4 it will be seen that the effect of closing PR1(A)R is to connect the top circuits of this figure to one side of the 15 volt supply source 20.

Thus a circuit is completed to energize the electro-pneumatic valve EPV1 through closed contacts PR1(A)R, R5A2 and R6A2. EPV1 thus operates to open the door 12 in the set of doors A and equalize the air pressure on either side of these doors, as door 12 opens, the contacts EPV1N are closed to complete a circuit to the electro-pneumatic valve EPV2 (main doors) through PR1(A)R to source 20. EPV2 is thus operated causing cylinder 6 to open the doors 1 of set A.

If consideration is now given to the light indicating circuit shown in Figure 5 it will be seen that in the original condition with all the doors closed the three sets of lights will all be set at green. The set A of lights are controlled by relay R7 and the B and C by relays R8 and R9 respectively. In one position of the relay contacts when relays R7, R8 and R9 are all energized the respective contacts R7G, R8G and R9G are all closed connecting the green lights to source 20 and disconnecting the red lights, whereas when these relays are not energized the contacts change over opening respectively R7G, R8G, R9G and closing R7R, R8R and R9R to supply 20 to illuminate the red lights. In the initial condition with all doors closed PR1(A)N is closed connecting R7 to bridge 21 through closed contacts R1N (indicating the doors A are closed), R5N (indicating that escape door B is closed) and R6N (indicating that escape door C is closed). This energizes R7 so that R7G closes and R7R opens to illuminate the green A lights and not the red A lights.

In the B doors' circuit PR1(B)N is closed, R2N is closed (B main doors closed), R4N is open (escape door A open) and R6N is closed (C escape door closed). This causes R8 to be de-energized so that the red lights on door B are illuminated. Similarly in the C doors' circuit PR1(C)N is closed, R3N (C doors closed), R4N (A escape door open) and R5N (B escape door closed) are all closed de-energizing R9 and the red lights on door C are illuminated.

When, on starting the operation to open the A set of doors, relay PR1(A) was energized and changed over to condition PR1(A)R, then contacts PR1(A)N in the series circuit to relay R7 opened cutting off current to R7 allowing its contacts R7G to open and R7R to close. Consequently the green lights of doors A went out and the red lights went on. As EPV1 operated, contacts PVA4 (Fig. 3) opened cutting off the supply to R4 so that in Fig. 5 contacts R4N opened cutting off the supply to R8 and R9 causing the respective contacts to change over to open R8G and R9G and close R8R and R9R. Thus all the red lamps are illuminated on all three doors and all the green lamps are extinguished.

As EPV1 operated to open door 12 it closed contact EP1N to energize EPV2.

This in turn caused EPV2N to close to bypass open contact PR1(A)N and thus re-energize R7 to open R7R and close R7G to cause the green light on doors A to illuminate with the doors open.

Besides this visual warning given, the opening of doors A also set interlocks to prevent doors B and C opening. Thus, in Figure 2 as soon as PR1(A) was energized and reversed, the contacts PR1(A)N in the circuits of relays PR1(B) and PR1(C) opened preventing current from reaching these relays through door switches B and C if these switches were operated. Furthermore, the circuits are also broken by the opening of the contacts R4B1 and R4C1 as soon as EPV1 operates to open the escape door 12 of doors A and contacts PVA4.

With the doors open persons can pass through and when they are on the other side of bulwark 2 the close switch 17 on the panel 15 on the said other side can be operated. The sequence of operation is seen in Fig. 3 to which reference is now made. Since one side of rectifier 21 is connected to switches 17 through contacts PR1(A)R of the polarized relay PR1(A) and through closed emergency stop switch ESA relay R1 is energized to close self-holding contacts R15 across the door switch 17 to keep the relay energized and to close contacts R1A2 in the circuit of EPV4 to connect this valve to the supply source 20 through contact PR1(A)R. When the valve is energized it operates cylinder 6 to close doors 1 of set A. As soon as the doors are closed this operates proving switch PVA1 (Fig. 2). The contacts of this switch close to complete a circuit from the rectifier bridge 21 through closed contacts PR1(B)N, PR1(C)N, R5A1, R6A1, PR1(A)R, coil PR1(A), contacts R1A1 and PVA back to 21. PR1(A) is thus energized in the reverse direction and changes over. PR1(A)R thus opens cutting the supply to PR1(A) (Fig. 2) and to R1 (Fig. 3). The various contacts of R1 revert to their previous condition. The opening of the PR1(A)R contacts also remove the supply to the three valves EPV1, EPV2 and EPV4. With no supply to EPV1 this valve is no longer held open since PR1(A)R has reverted to its original state and closes the pressure relief door 12 closes at the same time opening EPV1N in the circuit to EPV2 and closing PVA4 in the circuit to R4 (Fig. 3) to energize the relay. Contacts R4 associated with relay R4 are closed and since one set of these contacts R4A2 is in series with the relay EPV4 and the parallel sets of contacts R7G1, PR1(B)R and PR1(C)R as soon as the lights change to green and R7G1 closes EPV4 is energized to hold doors A closed positively.

In the lighting circuit (Fig. 5) since relay PR1(A) has reversed to its normal condition contacts PR1(A)N close also, through de-energization of R1 (Fig. 3), contacts R1N close completing a circuit through R5N and R6N to relay R7 causing it to be energized and open contacts R7R and close contacts R7G. Thus the red lights associated with the A set of doors extinguish and the green lights illuminate. As relay R4 becomes energized in the circuit of the pressure relief door 12 of doors A contacts R4N in the circuit of relays R8 and R9 close causing R8 and R9 to be energized and R8R and R9R to open and R8G and R9G to close illuminating the green lights of doors B and C and extinguishing the red lights.

In the event of a person trying to pass through the doors A while they are closing that person will have to tread on plate 8 or plate 9. Their weight will operate the switches under the plates and cause emergency stop switch ESA (Fig. 3) to open cutting off the supply to relay R1. The contacts R1A2 in the circuit to EPV4 (Fig. 4) will thus open cutting off the supply to this valve. Since EPV2 is still energized the doors 1 will revert to their open position. When pressure is taken off the plates 8 and 9 ESA will close and the door closing sequence will have to be restarted.

With a person now situated between sets of doors A and B and doors A closed, they proceed to doors B and operate the switch 16 of the doors to start the opening procedure. The sequence of operations is similar to that described above for doors A. With all other doors closed closure of switch 16 completes a circuit to polarized relay PR1(B), this changes over to close associated contacts PR1(B)R and open contacts PR1(B)N. Electro-pneumatic relay EPV5 is thus energized through R4B2 and R6B2 to open the pressure relief door 12 of doors B. As door 12 opens relay EPV6 is energized to operate cylinder 6 to open the doors B. The lights change from green to red in a manner similar to that described with reference to doors A. It will be noted that as R7G1 opens the previous circuit to EPV4 holding doors A closed should be de-energized, this is not so though, as the operation of PR1(B) has closed R7G1's parallel contact PR1(B)R and thus the energization of EPV4 is maintained and doors A are kept closed whilst doors B are open. The person then passes through the doors and operates the switch 17 of doors B on the other side of the bulwark 2 of doors B. As 17 is closed relay R2 is energized to operate its various contacts including R2B2 in the circuit to valve EPV8. EPV8 thus operates on cylinder 6 to close doors 1 of the set B and close proving switch PVB2 (Fig. 2) to reset PR1(B) to its normal

condition and cause the lights to change back to green.

The person now proceeds to doors C and closes one of the switches 16 to change over polarized relay PR1(C). Valve EPV9 is thus operated opening pressure relief door 12 and closing contact EPV9N to energize valve EPV10. This valve causes the set of doors C to be opened and the lights to be set again to red on all other doors. The person now passes through the doors and operates one of the switches 17 on the other side of the doors. This energizes relay R3 so that its contacts R3C2 may close to energize valve EPV12 and operate the door cylinder 6 to close the main doors. With the escape door closed the sequence is now complete.

It will be clear from the above description that the three sets of doors are fully interlocked and that each door circuit is interlocked with the others to prevent more than one set of doors being opened at any one time. Also the incorporation of switches ESA, ESB, ESC as emergency stop switches adds a significant safety feature to the circuit since it prevents any person becoming trapped between closing doors. Since the doors, in the example described, are operating in a pressurized system, the extent of injury which could be occasioned by anybody being trapped between closing doors is likely to be great. The present invention has avoided this.

The use of a simple but positive signalling system using lights enables a person in any position relative to the doors to be aware of the state of the system.

In the event of two people trying to operate switches simultaneously in respect of different sets of doors the system will fail-safe and cancel and each person will have to operate their switches again.

WHAT WE CLAIM IS:—

1. An antomatic door operating system comprising in combination at least three doors spaced apart from each other in line in a tunnel and electrical circuitry interlocking the doors, wherein the electrical circuitry comprises, in respect of each door, first switch means adapted to initiate opening of the door, second switch means adapted to initiate closing of the door, polarized relay means associated with each first switch means, and operating means respectively for the doors; the relay means of each door being connected with the operating means of the other doors in such a manner as to isolate the said operating means of the other doors when one of the doors is opened; indicating means associated with each door arranged to indicate whether or not the operating means for that door is isolated and further switch means connected to prevent closure of a door when an object is passing through, or within predetermined distance of the door.

2. A system as claimed in Claim 1, wherein the operating means comprises an electro-pneumatic or hydraulic valve controlling a piston and cylinder arrangement.

3. A system as claimed in either preceding claim wherein the indicating means are lamps.

4. A system as claimed in any preceding claim in which the further switch means is a switch directly operated by the weight of a person or object.

5. A system as claimed in Claim 4, wherein the further switch means is a pressure operated switch.

6. A control system substantially as herein before described with reference to the drawings accompanying the provisional specification.

For the Applicants
J. I. WOOD,
Chartered Patent Agent.

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1485981 PROVISIONAL SPECIFICATION
5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

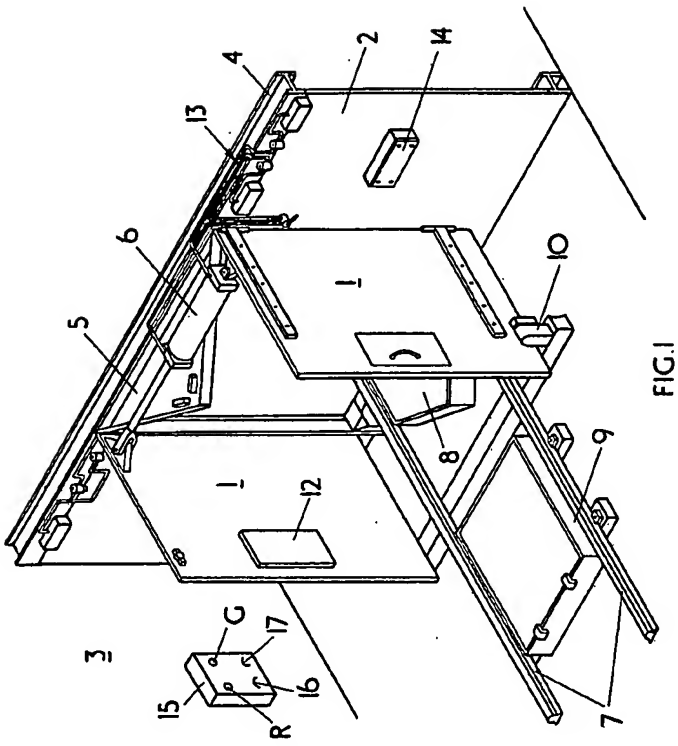
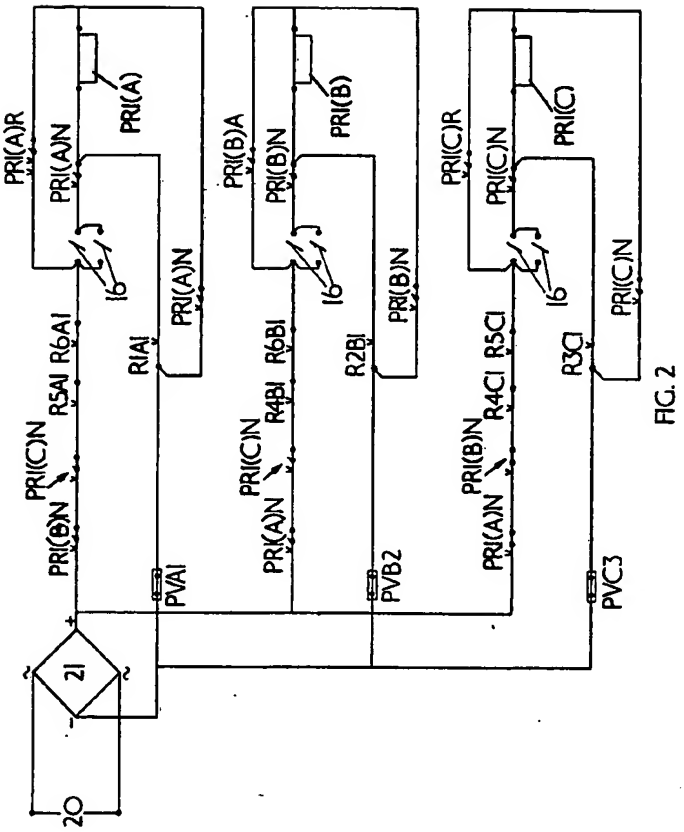


FIG.1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PRI(A)N
PRI(A)
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PRI(A)N
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PVA1
PRI(B)A
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PRI(B)
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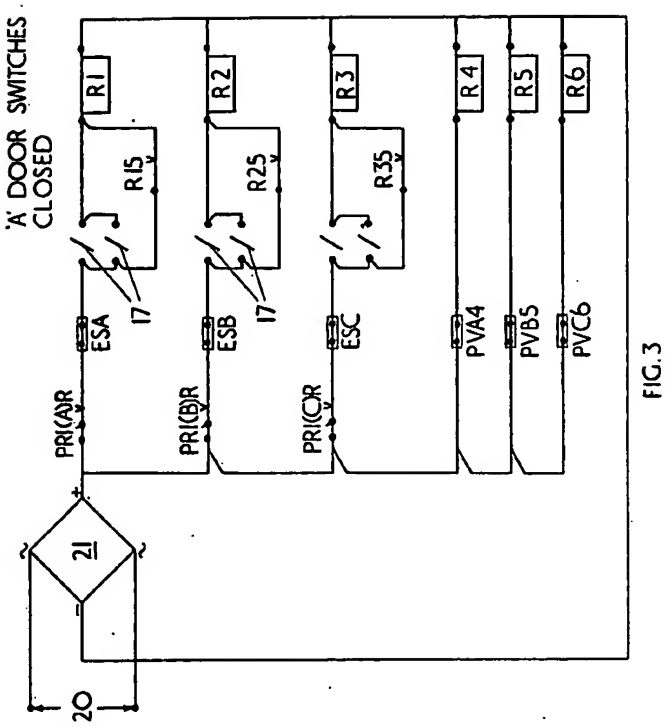
20

FIG. 2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R2
R3
R4
R5
R6
R15
R25
R35
17
17
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ESB
ESC
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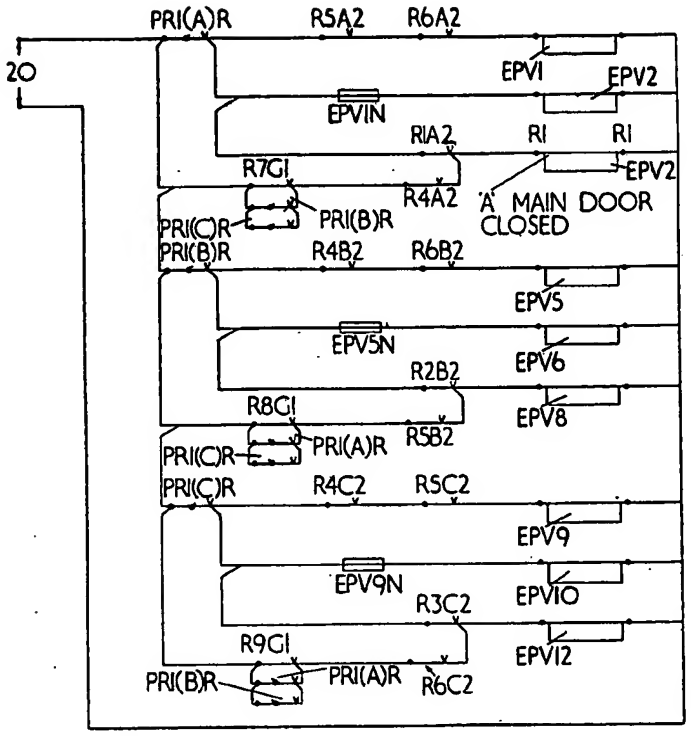
PRI(C)R
21
20

FIG.3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R6A2
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EPV2
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R4A2
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PRI(B)R
PRI(B)R
R4B2
R6B2
EPV5
EPV5N
EPV6
R2B2
R8G1
EPV8
PRI(C)R
PRI(A)R
R5B2
PRI(C)R
R4C2
R5C2
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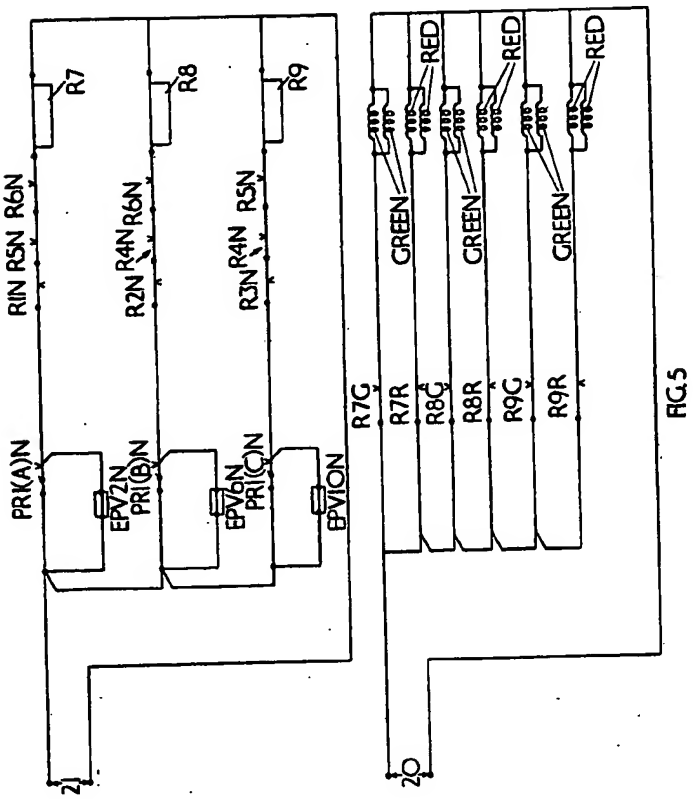
FIG. 4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R9
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EPV2N
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R8G
R8R
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